Demonstration of the Vortex Process for biomass gasifiers

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Introduction

Thermal gasification of biomass still holds many challenges within research and development. One of the main problems is tar production, which is an operational problem as well as an environmental problem. Around the world research and development is carried out on a wide range of gasification processes, in order to minimise the tar production or to develop efficient gas cleaning methods.

At the Technical University of Denmark a new simple type of gasification process with very low tar production is under development: The Vortex Process. In this abstract the new process will be described for the first time, and there will be a presentation of the experiments carried out in order to verify the process.

The vortex gasifier

The vortex process is a down draft gasifier, where the pyrolysis and the char gasification take place in one unit.

The gasification agent is preheated air supplied at the top of the gasification chamber in such a way that a horizontal rotating movement of the air is created. This movement of the air will induce secondary flows in the boundary layer at the top of the char bed. The secondary flows will create an upward flow in the centre of the gasification chamber.

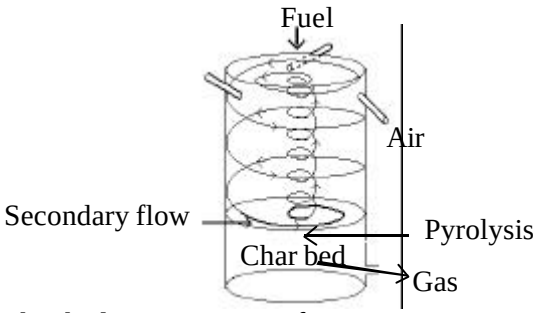

Figure 1 The flow above the char bed in a vortex gasifier.

Since the pyrolysis take place in the upper layers of the bed, the upward flow will bring the volatile pyrolysis products to the top of the gasification chamber above the char bed. Here the supply of air will cause a partial combustion of the volatile pyrolysis products. Hereby the temperature will rise to approximately 1100 ?C causing a thermal cracking of the pyrolysis tars. Due to this the content of tar in the producer gas will be lower for the vortex process than for ordinary down draft gasifiers. This is an advantage when operating the gasifier and in terms of environmental effects.

The high temperature above the bed, causes high temperature gas radiation to the bed. Hereby the biomass will undergo pyrolysis in the top of the bed faster than for other down draft gasifiers.

The vortex gasifier combines the simple design of a one stage down draft gasifier with an expected low tar content. This makes the vortex gasifier very interesting for further investigation and verification.

Experimental results

In experiments using three different settings, selected features of the vortex process has been examined. The experiments had two objectives; one was to examine whether or not the flow behaved

as predicted. The other was to determine a minimum diameter of the gasification chamber when using the vortex process in a 2 $MW_{thermal}$ plant.

Flow experiments
The former objective was primarily examined through cold flow experiments carried out in a transparent reactor containing wood chips. The airflow pattern was determined by sending smoke into the reactor. In addition measurements of the dynamic pressure and the static pressure were made. These examinations were carried out for a number of different flow rates, different shapes of the reactor, and different angling of the air nozzles.

In addition warm flow experiments has been carried out in a 100 $kW_{thermal}$ down draft gasifier at the Technical University of Denmark. The gasifier was operated as a vortex gasifier for one day. The expected flow was confirmed by visual observation of a vortex and by temperature measurements.

The cold and the warm experiments clearly stated that under various conditions the flows were as expected.

Pyrolysis time
The possibility for the vortex process to be used in a 2 $MW_{thermal}$ plant has been investigated. This does amongst others depend on the pyrolysis time for the wood chips, as the wood chips must be completely pyrolysed before they leave the zone with secondary flows. If this is not the case the volatile pyrolysis products will not be brought to the hot area at the top of the gasification chamber by the secondary flows and there will not be a tar reduction due to thermal cracking. Therefore the pyrolysis time is crucial for deciding the diameter of the gasification chamber, if a low tar content is required.

The pyrolysis time for wood chips has been examined by the application of two different methods in two different settings. In the 100 $kW_{thermal}$ gasifier the pyrolysis time has been determined by measuring the time from the wood chip enters the hot gasification chamber until the colour of the chip has changed to that of the rest of the char in the bed. The results indicate that the average time for the pyrolysis of wood chips in a vortex gasifier is app. 1½ minute.

For the other pyrolysis experiments a macro thermo gravimetric analysis unit (TGA) has been designed. Here the mass of up to 30 g of wood chips was measured continuously during the pyrolysis. The temperature in the TGA was varied between 400 ^{o}C and 1100 ^{o}C and wood chips of different sizes and moisture contents were used. The pyrolysis time was measured as the time passing from the wood chips entered the unit until the mass had stabilised. These experiments showed that the pyrolysis time and the share of char decreased with increasing temperature. Under conditions similar to those in a vortex gasifier the pyrolysis time for wood chips was estimated to 1-3 minutes. On account of this pyrolysis time it has been estimated that the diameter of the reactor in a vortex gasifier of 2 $MW_{thermal}$ should at least be of the order of 1 meter. This should not cause any constructional problems.

Conclusion
It has been experimentally demonstrated in three different settings, that:
?? The flow pattern above the bed behaves as expected
?? The pyrolysis happens within an acceptable time frames

On this basis it is concluded that it is very likely that the vortex process will work with a very low tar production. It is expected that there is a major potential for this new gasifier design with a good chance of realisation. Due to the very simple construction this type of gasifier might be highly suitable in developing countries.

There have been applied for a patent on the vortex process.